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HOW TO PILE TURNING SQUARES FOR RAPID AIR SEASONING

by ROY M. CARTER

NORTHEASTERN FOREST
EXPERIMENT STATION

Forest Products Paper No.1
January 1946

United States Department of Agriculture

FOREST SERVICE
NORTHEASTERN FOREST EXPERIMENT STATION

614 Bankers Securities Building
Philadelphia 7, Pennsylvania

V. L. HARPER, DIRECTOR

FOREST UTILIZATION SERVICE
James C. Rettie, Chief

This is the first of a series of Papers on methods of improving air seasoning and kiln drying practices in the wood turning industry. Other Forest Products Papers on seasoning are:

No. 2. Piling and Its Effect on Drying in Natural Circulation Kilns
No. 3. Principles of Design That Affect the Operation of A Natural-Circulation Kiln
No. 4. A Method of Determining the Heating Coils Required In A Natural-Circulation Kiln
No. 5. Control Devices for Regulation of Dry Kilns
No. 6. Schedules for Drying Turning Squares in Natural-Circulation Kilns

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This series of papers on seasoning and kiln drying has been prepared especially for the turning industry; however, many of the other woodworking industries may be able to apply the principles of drying presented.

HOW TO PILE TURNING SQUARES FOR RAPID AIR SEASONING

By Roy M. Carter[1/]

The seasoning of wood squares and other stock for the turning industry has, in past practice, involved a combination of air seasoning and kiln drying. Thoroughly air-seasoned squares have a moisture content of 15 to 25 percent, depending upon local weather conditions, but this is not low enough for the better turned products. Therefore, the stock is dried in a kiln or some kind of drying compartment before turning. Highest quality symmetrical products are turned when the stock has a moisture content of between 6 and 10 percent as determined by the species of wood and the type of lathe being used.

Squares sawn principally in the autumn, winter and spring months are piled in yards or open sheds. An effort is made to keep from 12 to 18 months' production on the stickers at all times, thus providing an ample supply of air-seasoned stock for further drying and turning. During the past few years, however, the scarcity of labor in the woods, coupled with an urgent demand for increased output by the turneries, has caused a shortage of air-seasoned material. Partially air-seasoned and green squares have been placed in "hot-boxes" or heated compartments in an effort to speed up drying. Most of these compartments are not designed to handle green squares, and have therefore failed to give good results. Other papers in this series deal with drying in heated compartments. The purpose of this paper is to show how, by proper piling, the time required for air seasoning can be somewhat shortened.

1/ Specialist on Manufacture and Fabrication, Division of Forest Utilization, Northeastern Forest Experiment Station.
Prepared in collaboration with the staff of the Division of Timber Physics, Forest Products Laboratory, Madison, Wisconsin.

General Principles of Wood Drying

In the drying process wood first loses the free water which is contained in the cell cavities. This loss occurs quite rapidly and causes no appreciable shrinkage of the wood. When all this free water has passed out, the moisture content of the wood has dropped to something like 30 percent. This is known as the fibre saturation point. Reducing the moisture content still further, requires the evaporation of water held in the walls of the cells. Extraction of water from the cell walls, and its subsequent evaporation progresses slowly under air seasoning. This is an advantage in some respects, because shrinkage and drying defects such as checks, collapse and honeycomb occur during the removal of moisture from cell walls. Damage is less likely to occur when the process is gradual.

The moisture in the interior of a piece of wood can reach the surface in two forms: either as liquid or as a vapor moving through the capillary channels and cell walls. In either case the movement goes on continuously so long as there are within the wood, moist regions and drier ones. The movement outward will continue only while the moisture at the surface is being evaporated.

The rate of evaporation depends upon temperature and relative humidity.[2/] Table 1 shows the moisture capacity of air at various temperatures at sea level pressure:[3/]

2/ Relative humidity is defined as the amount of vapor in the air expressed as a percentage of the amount it could hold at saturation.

3/ United States Department of Agriculture Technical Bulletin No. 174, THE AIR SEASONING OF WOOD, by J. S. Mathewson. P. 7.

NORTHEASTERN FOREST EXPERIMENT STATION
614 Bankers Securities Building
Philadelphia 7, Pennsylvania

RP-NE
SEASONING
General

January 22, 1946

Dear Sir:

Enclosed is the first of a series of Papers on seasoning and kiln drying prepared especially for the turning industry. The other Papers have not been completed but will be sent to you when distribution is made. Additional copies of Forest Products Paper No. 1 may be obtained by writing this Station.

These Papers were prepared as a result of numerous questions on air seasoning and kiln drying that were brought up during visits to wood turning plants in the northeast. Representative mills were included in the preliminary survey by the Forest Utilization Service and Forest Products Laboratory. It was felt that other turning plants might have similar questions which could be answered by short papers covering most of the problems incompletely discussed during our contacts. If your questions have not been fully answered, or others occur, the Forest Utilization Service will be glad to hear from you.

The Forest Utilization Service has been established in the northeast to assist logging and wood using industries in their application of the latest research and developments, some of which have been restricted during the war. In addition, the Service maintains liaison with the Forest Products Laboratory, Madison, Wisconsin, whereby problems disclosed at plants, such as wood utilization and manufacturing or assembly problems from milling to the finished products, can receive proper attention. The Service will endeavor to give you direct advice and assistance on questions referred to this office.

Sincerely yours,

V. L. HARPER, DIRECTOR

By R. F. Taylor

R. F. Taylor, Acting

Enclosure

Table 1

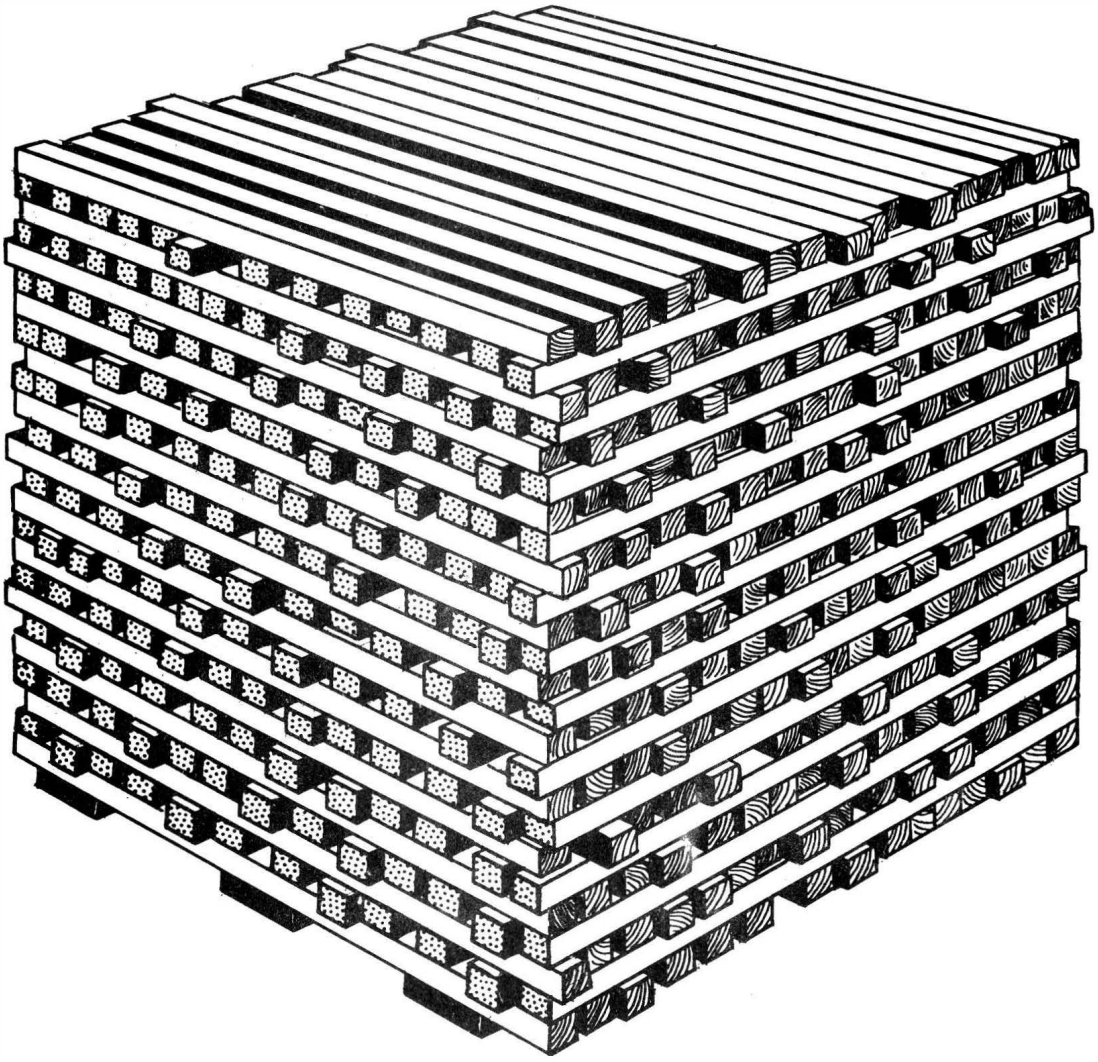
Temperature	Weight of Moisture at Saturation
20 degrees F.	1.2 Grains per cubic foot
40	2.9
60	5.8
80	11.1
100	20.0

Air in contact with the surface of the drying wood soon reaches its saturation point. It is, therefore, necessary to insure that air will constantly circulate over all the exposed surfaces in order to dry the wood as rapidly as possible. This is done by arranging the piles and stock in the piles so air can circulate.

Methods of Piling

In air seasoning, the temperature and relative humidity can not be controlled, but the rate of air circulation can be influenced by the method of piling. As moisture evaporates from the wood surface, the air cools and becomes heavier. The natural movement of heavier air is downward. Flues and chimneys of the right size and properly located in the pile permit this heavier air to drop, drawing fresh currents in behind it. This increases air circulation, provides more uniform drying throughout the pile and increases the rate of seasoning. In addition adequate space should be provided between the pile and its cover, and between the bottom of the pile and the ground to permit free movement of air into the pile, down through it and out. In the courses or layers, and between the flues, squares, if one inch or larger, should be placed $\frac{1}{4}$ inch to $\frac{1}{2}$ inch apart, according to size. The following sketches illustrate two poor methods of piling and then show a method which will give good results in the shortest possible time.

POOR PILING



What is Wrong with this Piling ?

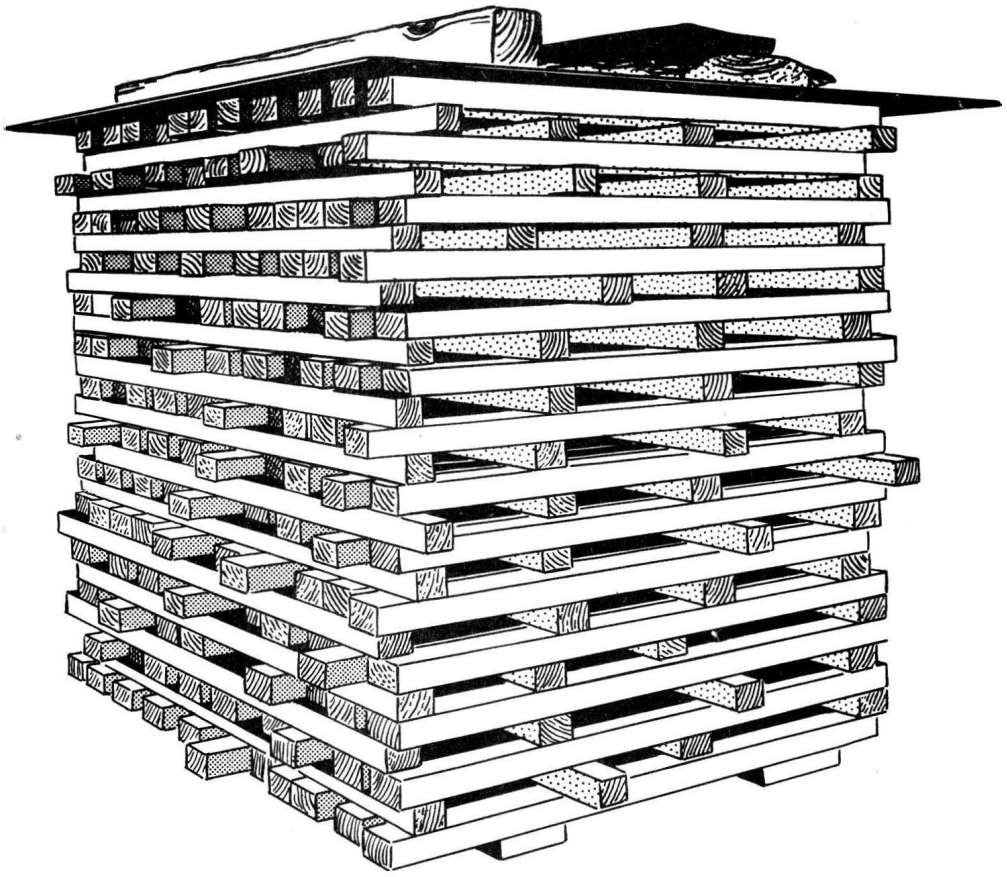
1. No foundation... inadequate air circulation, encourages stain and decay.

2. Squares in solid alternating layers, without stickers between layers... provides neither vertical nor cross-circulation, very slow drying, increases blue stain and decay.

3. Covers not used... top layers unprotected.

4. Seasoning exceptionally slow... progresses from outside to center of pile.

MORE POOR PILING



What is Wrong with this Piling ?

1. Foundation too low and inadequate, obstructs air circulation and does not support each row of stickers.

2. Stickers out of alignment...often results in warping.

3. No flues or chimneys to aid air circulation.

4. No spacing between squares...slow drying may cause stain.

5. No space between roof and pile...poor air circulation.

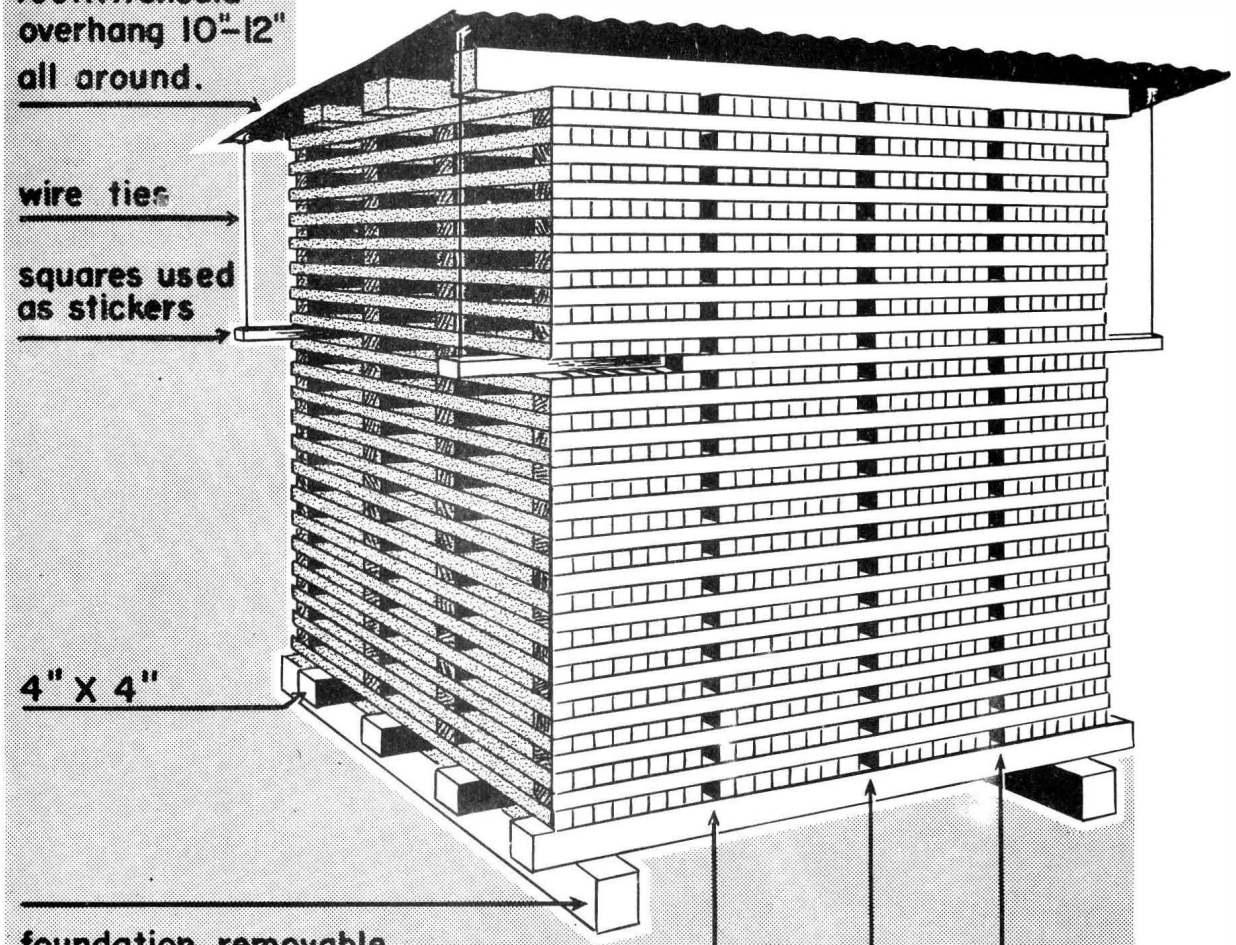
During the summer, wood dries rapidly. Freshly cut squares larger than 1½ inches may dry too fast and thereby check. This is more likely to happen to certain "hard-to-season" species like oak, beech, dogwood and persimmon. When seasoning these species in a warm dry summer, the flues should be smaller than shown in the sketches. Larger squares are more likely to be damaged by rapid air seasoning than are smaller ones. The reason for this is that the drying process sets up shrinkage stresses in the large square. In small squares the stresses do not build up because the central portion of the wood loses moisture as the surface dries. Species like aspen, basswood and white birch are "easy to season." These can be dried safely in piles which have flues even larger than shown in the sketches.

Piles put up early in the winter should also have wide flues. This tends to speed up the seasoning process in the months when it is naturally slow. By the time warm spring weather has arrived the drying will have advanced beyond the danger stage. As the winter season advances the size of flues in piles which are being put up should gradually decrease. As a general rule, piles made in the winter have fewer seasoning defects than those put up in summer.

Covers and Sheds

Air seasoning piles need covers to protect them from exposure to the sun, rain and snow which may cause slow drying, warping, checking, and especially loss of top layers. A permanent type metal cover projecting over all sides, weighted or tied into place, is very satisfactory. Covers may also be made of low-grade boards placed in two layers. In the first layer boards may be placed ½ inch apart. The

A METHOD OF PILING SQUARES FOR RAPID AND UNIFORM AIR SEASONING


metal or wood roof. 4"-8" space between pile and roof.... should overhang 10"-12" all around.
wire ties
squares used as stickers
4" X 4"
foundation removable..... provides at least 10" or 12" between ground and squares for air circulation.....can be used as a pallet.....pieces are 4" X 6" or 4" X 8"
three 3" flues for vertical air circulation throughout pile

Foundation, roof and flues constructed to provide unobstructed channels for air to circulate.

top layer should be placed directly over the openings in the first layer. A space of 4 to 8 inches between the pile and cover is desirable for air circulation.

Air drying in sheds often decreases the drying rate. In an effort to utilize all the space, piles may be erected too close together to permit adequate air circulation. Sides and ends on sheds retard drying and are not recommended except as it is necessary to use them to protect squares from the sun, rain, and snow. If sheds are used, there should always be a generous space between the top of the piles and the roof. In some cases, ventilation outlets in the roof may permit higher piles. In all cases wide alleyways are desirable to aid air circulation and permit easy removal of the stock. Covers for each individual pile are, of course, not used in a shed. Piles in sheds can be made as high as convenient providing overhead space and solid, level foundations are adequate. Flues in shed piles can be made larger. Space between piles and floor should be at least 12 inches. Seasoning in sheds requires a longer period than yard piling unless exceptionally wide alleys, flues, and room for air movement is provided. Because of the more gradual process, shed piling is desirable when large squares or species especially subject to checking are to be seasoned without defects.

ADDITIONAL REFERENCES

Publications by the Forest Products Laboratory, Madison, Wisconsin. Copies can be obtained without charge from the Laboratory or the Northeastern Forest Experiment Station, 614 Bankers Securities Building, Philadelphia 7, Pennsylvania.

Publications Nos. 8 and 9 can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. (Stamps not accepted.)

1. Technical Note 180. Comparative Strength of Air-dried and Kiln-dried Wood.

2. Technical Note 186. Coatings that Prevent End Checks

3. Technical Note 233. Approximate Air Seasoning and Kiln Drying Periods for Inch Lumber

4. Mimeograph 899-8. Air Seasoning at Small Mills, by J. S. Mathewson, 1932.

5. Mimeograph 1146. Electrical Moisture Meters for Wood, by M. E. Dunlap. Revised 1943.

6. Mimeograph 1174. Seasoning of Beech Lumber and Dimension Stock, by R. C. Rietz. 1938.

7. Mimeograph 1435. Coatings for the Prevention of End Checks in Logs and Lumber, by J. M. McMillen and W. Karl Loughborough. 1943.

8. Wood Handbook: Basic information on wood including a chapter on "Control of Moisture Content and Shrinkage of Wood", by Forest Products Laboratory, U.S.D.A. unnumbered publication, 1935. Revised 1940. 35 cents.

9. Air Seasoning of Wood, by J. S. Mathewson. U. S. Department of Agriculture Technical Bulletin 174. 1930. 35 cents.

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PILING AND ITS EFFECT ON DRYING IN NATURAL CIRCULATION KILNS

by ROY M. CARTER

NORTHEASTERN FOREST
EXPERIMENT STATION

Forest Products Paper No.2
February 1946

United States Department of Agriculture

FOREST SERVICE
NORTHEASTERN FOREST EXPERIMENT STATION

614 Bankers Securities Building
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The wood turning industry has been subject to competition with products made of other materials. In recent years the plastics industry has grown, while the turning industry has remained "as is", or declined. Developments in fabricating plastics and their increased production during the war point toward even greater competition. No one process can be modified in wood turning to offset this competitive movement. But, by starting with one of the simplest operations, seasoning, and by continuing minor modifications throughout drying, machining, handling and finishing until the product is completed, the turning industry can improve the quality of the products manufactured and make its future business position more secure. This is of special concern to many individuals and small communities whose principal economy depends upon the wood turning industry.

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PILING AND ITS EFFECT ON DRYING IN NATURAL-CIRCULATION KILNS[1/]

By Roy M. Carter[2/]

A natural-circulation kiln can be defined as a drying compartment or "hot-box" which relies solely upon differences in temperature to create the necessary movements of internal drying air. It does not have fans or blowers to force air to circulate in definite directions. Heat, supplied by the steam coils, causes air to move; but not necessarily through the pile of squares. Whether the air stream goes through the pile, thus drying the wood uniformly, or around the pile, where it dries only the outside, depends upon: (1) what provisions have been made in piling for air to move in a vertical direction; (2) the type and location of heating coils and (3) the air inlets and outlets.

This article presents piling practices that have been found to give good air circulation through the pile and to provide rapid, uniform drying throughout the kiln. The piling method shown may be applied to obtain more rapid and economical drying, without modifying existing kilns or obtaining new equipment. Information on heating coils, ventilation, controls and kiln operation will be presented in papers to follow.

Circulation in the Pile of Squares

Green squares in the kiln lose moisture to the drier heated air which comes in contact with them. Evaporation of water from a wood

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1/ In this Paper the wood material locally called bars, flats or slats can be treated as squares in the piling recommendations.

2/ Specialist on Manufacture and Fabrication, Forest Utilization Service, Northeastern Forest Experiment Station.
Prepared in collaboration with the staff of the Division of Timber Physics, Forest Products Laboratory, Madison, Wisconsin.

surface cools the air as it passes over the wood, increasing the unit weight of the air and causing it to drop downward. This draws new warm air over the surface to continue the drying. A pile of squares lacking adequate vertical flues for cooled air to drop through, thus creating circulation within the pile, dries very slowly.

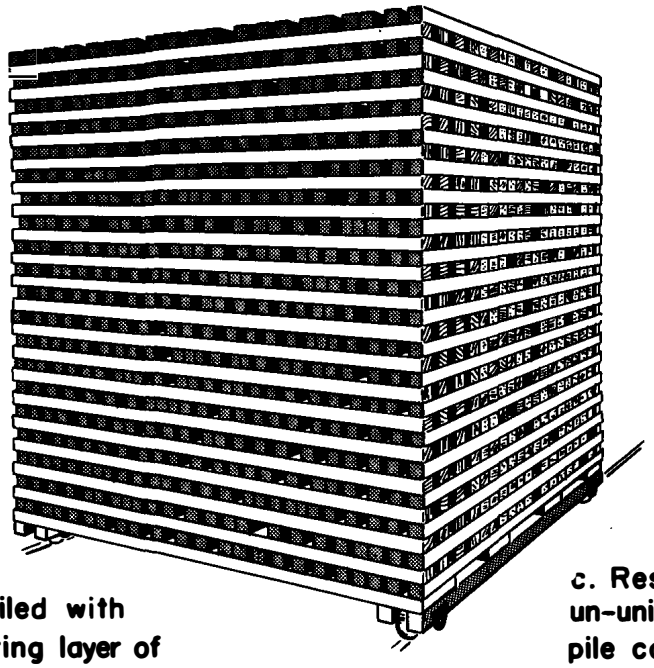
Horizontal movement of air, except as created by vertical currents, is generally insignificant in natural-circulation kilns. Nevertheless, piles made similar to those shown in Sketches No. 1 and 2 have been dried in kilns for a long time but at the expense of time and heat.

Cool, moist, air moving downward may become partially stagnant with consequent slow drying in the lower section of the pile unless sufficient area below the pile is provided for air removal. That is the reason for a space between the bottom of the pile and the heating coils.

Heat, radiated from steam coils, varies with the quantity of air in circulation; that is, as the speed of air circulation increases the greater the heat radiated per foot of heating surface. Methods of piling to obtain better air circulation, therefore, greatly influence the rate and uniformity of drying.

Piling squares in the kiln to obtain uniform circulation of air throughout the pile does not appreciably increase the costs of kiln drying. By providing flues for vertical movement of air a small reduction in total volume dired per kiln charge may result, but the loss of capacity can be more than recovered by more rapid drying of each charge.

GOOD AND BAD METHODS OF PILING FOR NATURAL CIRCULATION KILNS



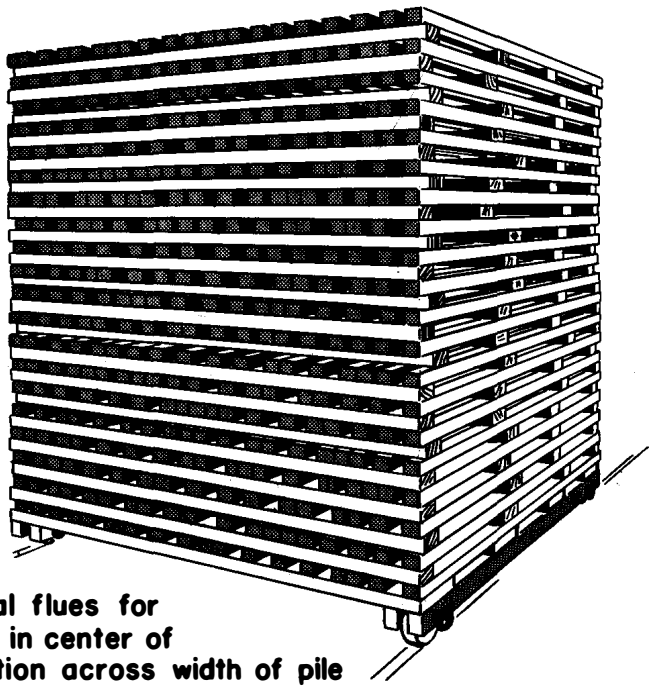
1.

WRONG :

a. Squares piled with each alternating layer of continuous squares (actually no stickers are used).

b. No vertical flues for air circulation within the pile .

c. Results : a very slow un-uniform drying rate; pile can dry only from exterior inward ; heat in kiln is wasted.



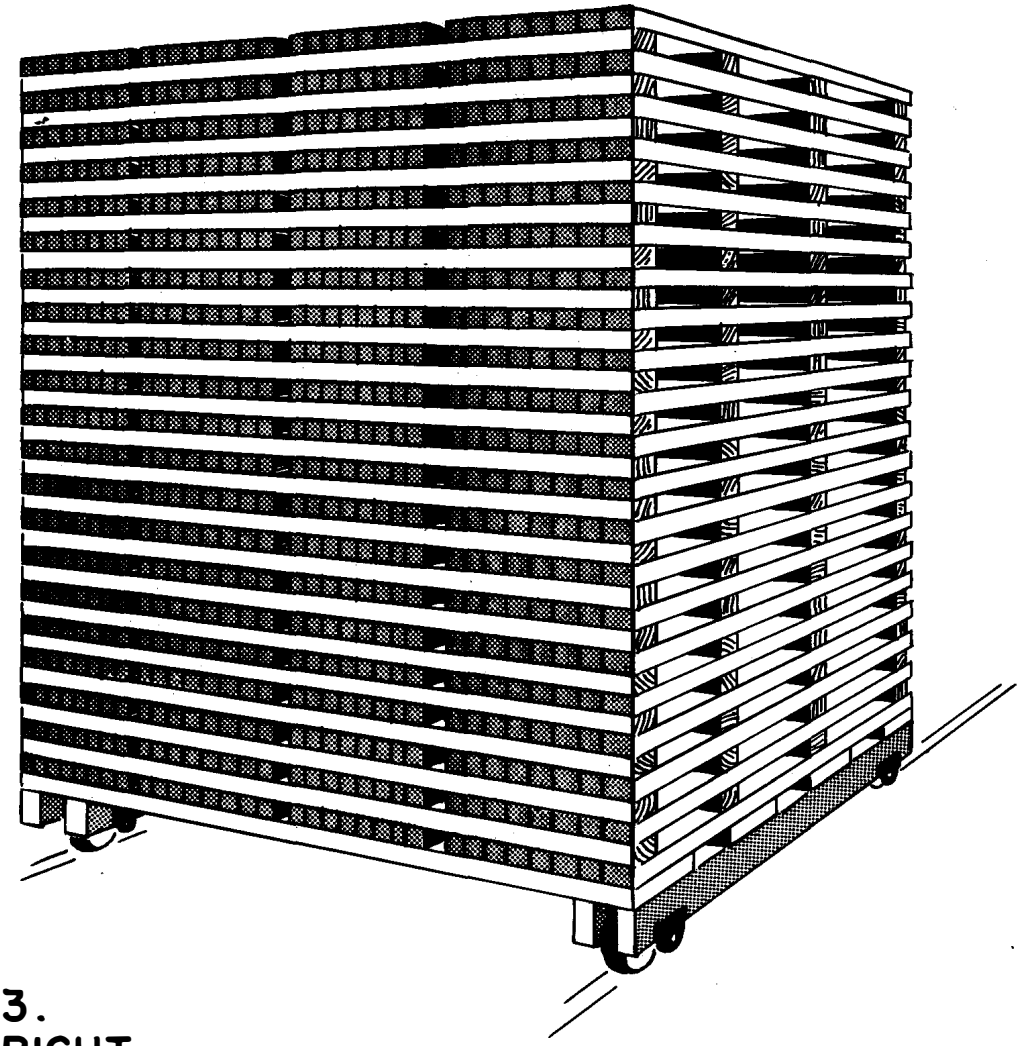
2.

WRONG :

a. No vertical flues for air circulation in center of pile . Circulation across width of pile is slow and drying is un-uniform with stagnant air pockets.

b. Stickers not in vertical alignment .

GOOD PILING FOR NATURAL CIRCULATION KILNS



3.

RIGHT

a. Three 3" vertical flues provide channels for air circulation and rapid uniform drying in center of pile.

b. Stickers vertically in alignment.

Piling Recommendations

In natural-circulation kilns a few piling suggestions should be followed for best results.

1. Allow 1½ to 2 feet between wall and pile for upward movement of hot air.
2. Using squares as stickers, space these stickers about twelve to sixteen inches apart and directly above each other. (Stickers for 2½-inch and larger squares should preferably be 1" by 1¼" to 2" slats, air dried, to permit a greater volume of squares per kiln charge and better drying. Stickers for all flat stock should be air dried 1" by 1¼" to 2" slats. Stickers, or squares 2" or larger, can project beyond ends of stock in each layer and thereby reduce end checking.)
3. Pile squares to form vertical flues at least three inches wide. There should be three flues in each four-foot pile of squares. Do not alternate the direction of solid layers or omit stickers.
4. Place squares, one inch and larger, about ¼ inch apart in each course.
5. Keep edges of flues even, to allow a free and rapid vertical movement of air.
6. Provide a space of at least 18 inches between pile foundation and steam coils.

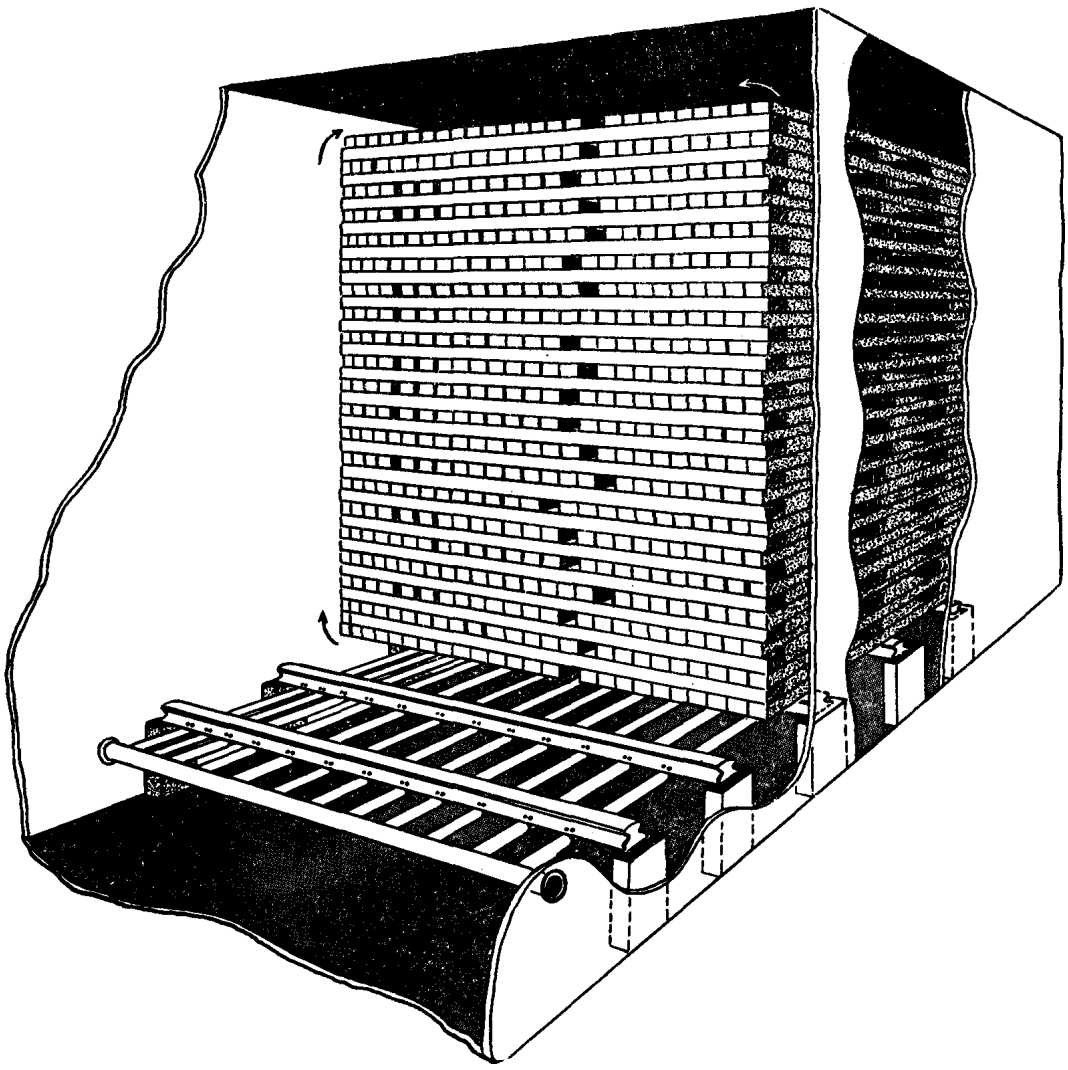
One method of maintaining flues of proper width and even edges is to place flue-width stakes on the ends of the kiln truck, pallet or foundation. Stakes inserted in U-shaped angles can be used as flue guides on one or both ends, removed and used over again.

Pile Location in the Kiln

Even when the squares are properly stacked in the kiln (or properly piled outside the kiln) poor drying will result if air circulation is obstructed when the kiln is loaded. Sketch No. 4 shows a charge improperly stacked in the kiln and Sketch No. 5 shows a good pile well located in the kiln.

Variations in kiln design, such as wall heating coils or a vertical battery of coils in the center between two or more piles, would still function satisfactorily if the general principles shown in Sketch No. 5 are applied. Baffles can be used in natural-circulation kilns, as they are in blower-equipped kilns, wherever required to force air down through adequately-made flues and prevent circumventing the pile.

POOR PILING IN THE KILN



4. WRONG

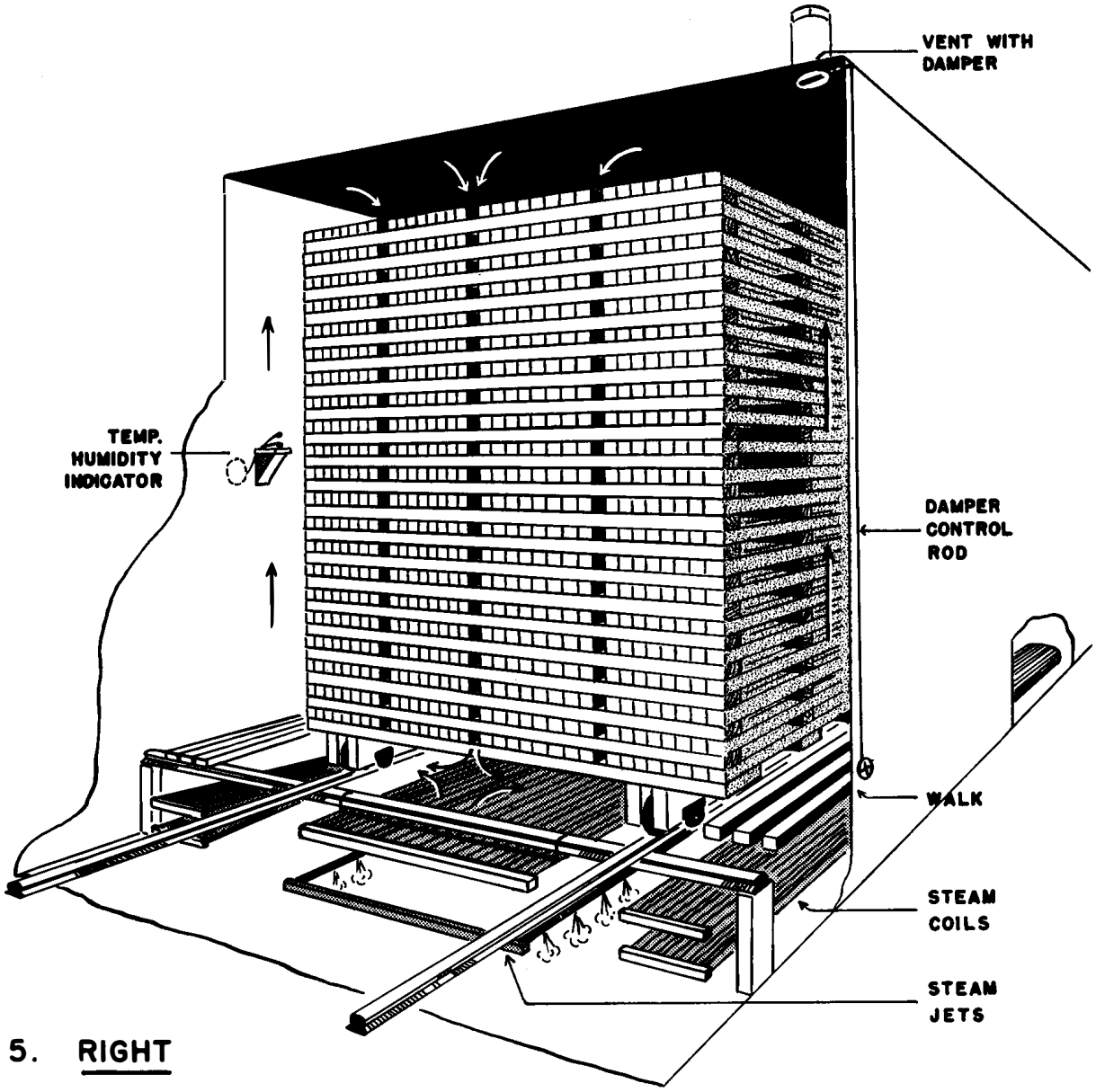
a. Pile too close to steam coils. Heat from coils prevents cool air from circulating downward. Causes wet spot in center of pile.

b. Flues obstructed or not built in pile.

c. Space between walls and piles inadequate.

d. No temperature or humidity control or indicators in the kiln.

GOOD PILING IN NATURAL CIRCULATION KILNS



5. RIGHT

a. One and one-half to two feet between squares and wall.
b. Space under pile of 2' to 3'. Coils 18" from pile.
c. Steam sprays available to add desired moisture or humidity.
d. Temperature-humidity indicator located midway between wall and pile.
e. Good flues provided for removal of cool moist air from center of load.
f. Side coils used to create circulation. (Coils on sides used when squares are wet; center coils may be used to finish drying — side coils shut off — this reverses circulation.)

ADDITIONAL REFERENCES

Publications prepared by the Forest Products Laboratory, Madison, Wisconsin. Copies may be obtained without charge from the Laboratory or the Northeastern Forest Experiment Station, 614 Bankers Securities Building, Philadelphia 7, Pennsylvania.

Bulletins Nos. 12 and 13 can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. (Stamps not accepted.)

1. Technical Note 186. Coatings That Prevent End Checks.

2. Technical Note 233. Approximate Air Seasoning and Kiln Drying Periods for Inch Lumber.

3. Technical Note 199. Air Circulation in Dry Kilns.

4. Mimeograph 509. Relation of Moisture Content and Drying Rate of Wood to Humidity of the Atmosphere, by Arthur Koehler. 1941.

5. Mimeograph 1174. Seasoning of Beech Lumber and Dimension Stock, by R. C. Rietz. 1938.

6. Mimeograph 1242. Seasoning Dimension Stock, by O. W. Torgeson. 1932.

7. Mimeograph 1264. The Drying Rate of Sugar Maple as Affected by Relative Humidity and Air Velocity, by O. W. Torgeson. 1940.

8. Mimeograph 1267. Uniformity of Air Distribution in a Lumber Dry Kiln, by O. W. Torgeson. 1940.

9. Mimeograph 1269. Why the Drying Time of A Kiln Load of Lumber Is Affected by Air Velocity, by O. W. Torgeson. 1941.

10. Mimeograph 1435. Coatings for the Prevention of End Checks in Logs and Lumber, by J. M. McMillen and W. Karl Loughborough. 1943.

11. Theory of Drying and Its Application to the New Humidity-Regulated and Recirculating Dry Kiln, by H. D. Tiemann. U. S. Department of Agriculture Bulletin 509. 1917.

12. Wood Handbook: Basic Information on Wood, by Forest Products Laboratory. U. S. Department of Agriculture unnumbered publication. 1940. 35 cents.

13. Kiln Drying Handbook, by Rolf Thelen. U. S. Department of Agriculture Bulletin 1136. 1929. 30 cents.

Partial List of Books on Seasoning (available from publishers)

1. Kiln Drying of Lumber, prepared in the Extension Division of the University of Wisconsin, by Arthur Koehler and Rolf Thelen. (Indus. Educ. Ser.) New York City, McGraw-Hill Book Co. 1926. $3.00.

2. Air Seasoning and Kiln Drying of Wood, by H. L. Henderson. Published by J. B. Lyon Co., Albany, N. Y. 1939. $3.50.

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PRINCIPLES OF DESIGN THAT AFFECT THE OPERATION OF A NATURAL CIRCULATION KILN

by ROY M. CARTER

NORTHEASTERN FOREST
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Forest Products Paper No.3
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PRINCIPLES OF DESIGN THAT AFFECT THE OPERATION OF A NATURAL-CIRCULATION KILN

by Roy M. Carter[1/]

Actual designs of natural-circulation kilns vary in construction materials, structural arrangements, coil systems and operational requirements. Even though these differences in detail occur, three essential features in kiln operation must be considered to obtain efficient drying: (1) heat, (2) relative humidity control and (3) air circulation.

The Function of Heat

Heat is necessary to increase the rate of evaporation of moisture from the wood surface. As evaporation takes place it has a cooling effect on the air which then requires additional heat to hold the drying temperature. The capacity of air to take up or hold moisture is also increased as it is heated, as shown in Forest Products Paper No. 1. Temperatures, approaching the boiling point of water, cause a rapid transfer of moisture from the interior to the surface of wood. Wood, when heated, becomes more pliable, gives up its moisture more readily, and decreases resistance to movement of liquid. In fact, after wood has dried to about 30 percent moisture content (fiber saturation point) more heat is required to separate the water from the wood. Another important function of heat in natural-circulation kilns is to create circulation of air within the kiln and throughout the pile of stock. Thus the air not only carries

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1/ Specialist on Manufacture and Fabrication, Forest Utilization Service, Northeastern Forest Experiment Station.
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the drying heat, but it helps to circulate itself as a heat carrying agent.

The Function of a Variable Relative Humidity

During the several stages of drying, relative humidity in the kiln governs the ability of air to take up moisture. A balance between surface evaporation and the rate of diffusion from the center of the square to the surface is obtained by controlling the humidity. Relative humidity regulation, according to schedules, is necessary (1) to prevent or reduce surface and end checking, (2) to prevent or relieve case-hardening, (3) to regulate the final moisture content of the squares, (4) to bring all material in the kiln to an equal moisture content and (5) to maintain a proper rate of diffusion and moisture gradient from the center to the outside of the square.

The Function of Air Circulation

Air circulation in a natural-draft kiln is essential to bring the heat to the wood and carry off evaporated moisture. The air circulation rate and its uniformity determines, to a large degree, the distribution of temperature and humidity throughout the kiln. It also has a controlling influence on the efficiency of drying because the location of heating coils, vents and air inlets and the type of piling affect circulation.

Arrangement of Heating Coils

Properly fitting drying requirements together forms the basis for arrangement of heating coils in the design of a kiln. In a natural-draft kiln circulation is produced by differences in temperature. Evaporation of moisture from the wood cools the air. This increases its weight which causes it to drop downward. Therefore, during early stages of drying unseasoned material, the warm air, as it cools, should proceed down through

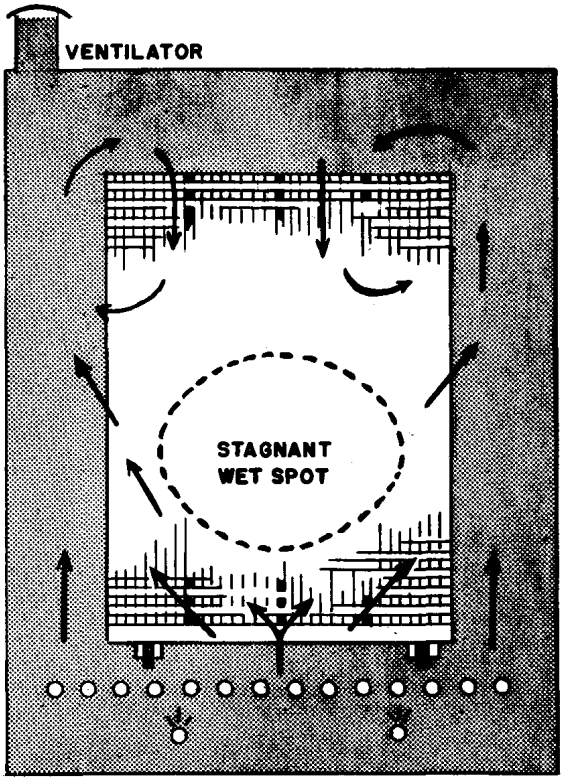
the pile. Space such as flues and areas above and below the pile should be provided for that purpose.

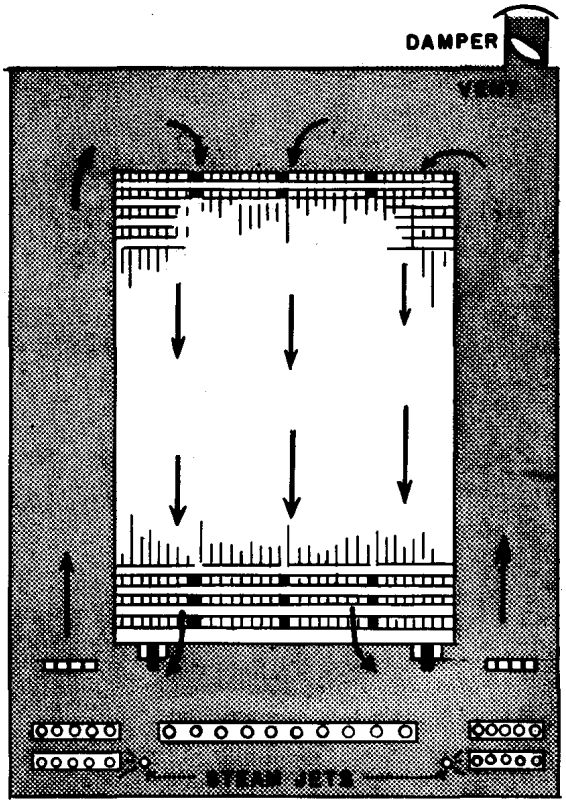
Coils directly under the pile as shown in Sketch No. 1, Page 4, are not recommended for drying green squares. Such coils produce a counteracting pressure of warm air rising against cool air falling. This generally develops "wet areas" in the lower center of the pile because of poor circulation. Drying is retarded until the center is dry enough to permit warm air to move upward through it. By that time the outer parts of the pile have become excessively dry and possibly damaged. Coils under the pile (Sketch No. 2, Page 4) should be turned off when squares are wet, but may be used in the last stages of drying when the heat can rise up through the pile. Thoroughly air-seasoned stock, piled with large flues in an open pile, may be dried by using a battery of coils under the pile if there is sufficient circulation to carry the warm air through the flues. However, the type of pile and kiln conditions seldom exist where coils under the pile work efficiently.

Heating coils near the walls or wall coils tend to heat the rising air which circulates up, then down through the piles, cools and recirculates. Recent experience in drying aircraft lumber indicates that when most of the coils were located under walks, on sides of kiln or between piles the results were more satisfactory than when all coils were located below the loads. In addition the heating coil system should be divided into separate units of 6 to 8 pipes per inlet header. When low temperatures are necessary a small full length unit maintains a more uniform efficient heat supply.

It is suggested that ample space, at least two feet, be provided under the pile to aid in allowing colder, damp air to drop out of the pile.

AIR CIRCULATION CREATED BY HEATING COILS





1. Poor Coil Arrangement

a. Air circulates all around pile but not through it unless very large flues are provided.

b. Slow drying wet spot in lower center.

c. Ventilators too large — some heat wasted.

2. Improved Coil Arrangement

a. Coils under walks direct air circulation up walls and down through squares.

b. Ventilators can be closed when necessary.

c. Coils under squares cut off during early part of drying. Used only in final stages to obtain sufficient heat when coils under walks may be shut off, thus giving reverse circulation.

A distance of about 18 inches between the load and the ceiling of the kiln is also recommended.

In case the kiln ceiling is not sufficiently insulated it may act as a condenser causing water to drip on the pile. If this condition exists a ceiling coil is sometimes provided and used in the early stages of drying when the humidity is high.

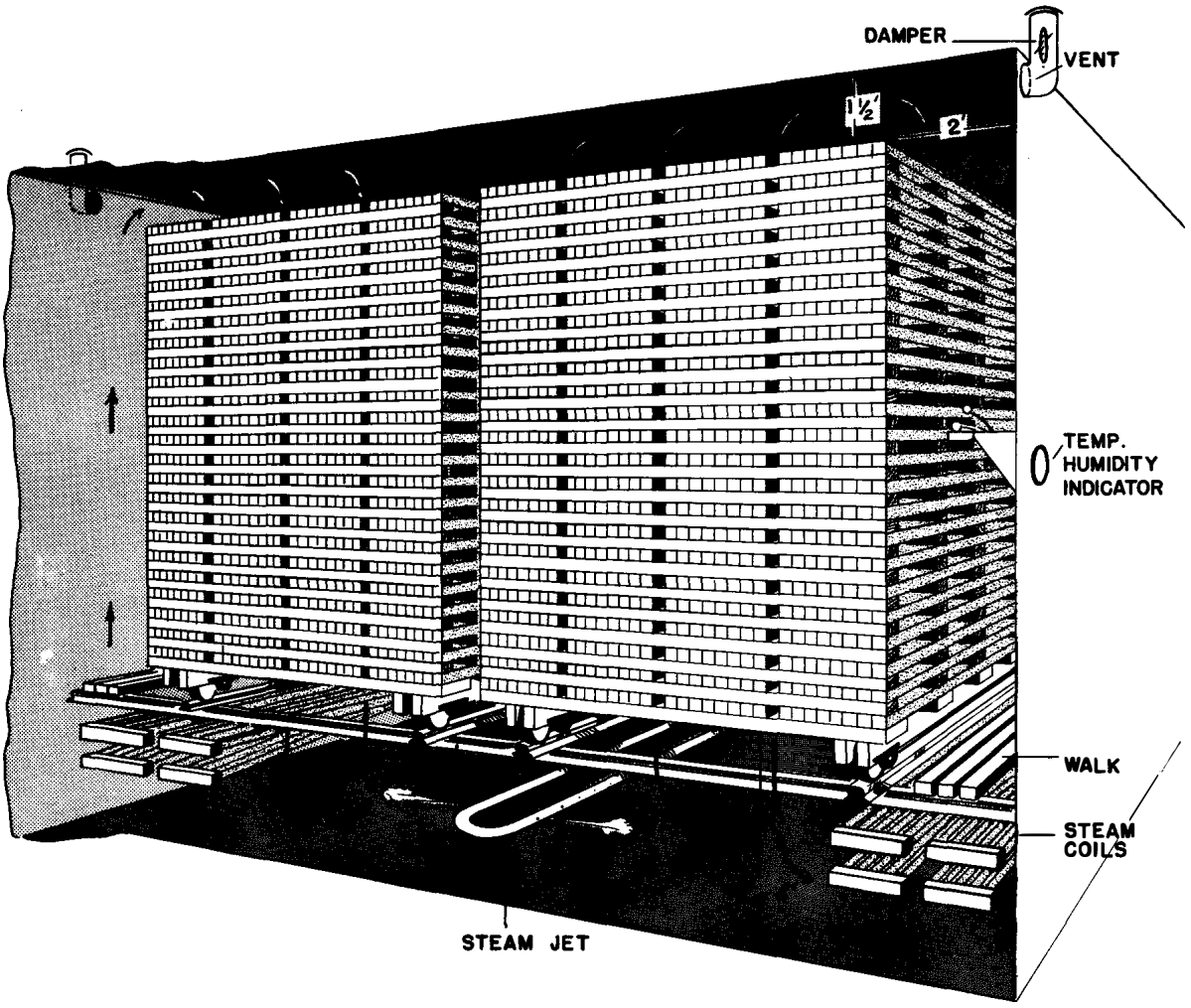
Kilns designed with coils located vertically above the rails and between the piles create circulation by heat rising. Baffles then can be used to force air through the pile instead of around it.

Separate steam pipe or pipes running the length of the kiln for humidity regulation purposes may be equipped with steam jets or merely holes for steam to escape. These steam sprays or, if desired, fine water sprays, should be located so that sprays will not hit the heating coils or affect the temperature-humidity instruments. Steam sprays can be located between the heat coils and the temperature controls. Water sprays may be placed there, also, or can be installed below the loads to aid in the downward movement of cooled air.

With heat coils located under the walks, kilns could be made wider than the 13-foot kiln shown (page 6). Walks, alleys or other channels $1\frac{1}{2}$ to 2 feet wide above the coils in which heat can rise would still be required for rapid drying.

Coil arrangement should be made to obtain maximum circulation within the kiln. Even the most rapid circulation in a natural-draft kiln can not equal forced-circulation kilns. The trend in the turning and lumber industry is to improve kilns by installing fans or constructing new fan kilns. The reason for this trend is because heat radiation from

A NATURAL CIRCULATION KILN



A NATURAL CIRCULATION KILN DRAWN ACCORDING TO THE SUGGESTIONS GIVEN IN THIS PAPER. DOUBLE 4' SQUARE PILES ON TRACKS IN KILN. RETURN-BEND COILS MAY BE LOCATED ON EACH SIDE UNDER OPEN WALK. IF DESIRED, ADDITIONAL COILS MAY BE PLACED UNDER THE PILES AND OPERATED DURING LAST STAGE OF DRYING. WHEN THIS IS DONE, COILS ON SIDES SHOULD BE TURNED OFF UNTIL DRYING IS COMPLETED. COILS UNDER PILES WORK SATISFACTORILY ONLY WHEN VERTICAL FLUES ARE ADEQUATE.
HORIZONTAL RETURN-BEND HEADER COILS WITH STEAM SUPPLY HEADER AND CONDENSATION RETURN HEADER ON DOOR END. FLUES AND STICKERS VERTICALLY ALIGNED. SPACE AROUND AND THROUGH PILES AMPLE FOR GOOD CIRCULATION. VENTS SHOULD BE PROVIDED WITH DAMPERS AND OPENED ONLY WHEN HUMIDITY IS TOO HIGH.

the same type of coil system in a kiln with forced circulation of 300 feet per minute is four or five times greater than in a good natural-circulation kiln.

Ventilation in the Kiln

The purpose of ventilation in a dry kiln is to remove excess moisture that has been evaporated from the wood. Frequently air outlets have been made for the mistaken purpose of creating air circulation. Sometimes these outlets have been excessively large, allowing heat to escape. This causes slow drying and a waste of steam. The most important fact in considering ventilation is that the air in the dry kiln moves primarily under the action of its own weight.2/ The apparent suction at inlets and draft at outlets is due to the fact that warm air rises and is being replaced by colder air.

Some dry kilns have sufficient leakage of air through cracks, doors, joints around eaves and similar openings to provide ample ventilation, but in the wrong places. For well-constructed kilns, controlled ventilation is necessary. In a double track lumber kiln 20 to 24 feet wide and 10 to 12 feet above rails, air outlets approximately 8 to 10 inches square for each 16 feet in length should be provided in the upper wall or ceiling. Kilns with equivalent leakage or outlets in excess of this may operate more satisfactorily with surplus vents cut off or closed.

Commercial kilns can now be obtained with automatic ventilator controls opening when moisture or relative humidity is greater than the drying schedule requires and closing when humidity is lowered. It is also desirable to regulate ventilators in all kilns by an appropriate damper

2/ Ventilation in a Dry Kiln by W. Karl Loughborough, Forest Products Laboratory Mimeograph R-1205, November 1931.

mechanism. This can be accomplished by installing either automatic or hand operated dampers in the ventilators which can be adjusted by the operator according to relative humidity conditions in the kiln.

Air inlets should be installed in a natural-draft kiln even though the kiln foundation and door are not tight. Some inlets should be spaced uniformly throughout the length of the kiln so that cold spots may be avoided.

Designing a kiln requires many calculations on heat consumption, heat loss, kiln size, volume of wood to be dried and numerous other engineering features. Some factors, occasionally not included in kiln design, such as heating coil location, separate coil control units, uniform steam flow in the coils, pile location, ventilation and temperature-humidity controls often make the difference between an efficient and inefficient kiln.

ADDITIONAL REFERENCES

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4. Technical Note 233. Approximate air seasoning and kiln drying periods for inch lumber.

5. Mimeograph 1031. List of dry kiln manufacturers and dry kiln engineers in the United States. 1941

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2. Air Seasoning and Kiln Drying of Wood, by H. L. Henderson. Published by J. B. Lyon Co., Albany, N. Y. 1939. $3.50